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## OCCUPATIONAL BIOMECHANICS OF THE LOW BACK.

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Low back pain (LBP), the most prevalent and costly work-related disorder, has often been associated with high or repetitive mechanical loading. In this respect it is not surprising that biomechanical modeling has a long-standing tradition in research related to the prevention of LBP. Theoretically one could think of several ways in which biomechanical modeling can contribute to the prevention of work-related low-back pain. Biomechanical methods and models could be applied to:

- evaluate alternative workplace layouts, working methods and techniques,
- detect the most stressful tasks and task elements in a function,
- set standards for workload and to compare MMH tasks against these standards,
- increase understanding of how MMH can cause LBP.

The multi-session symposium "Occupational Biomechanics of the Low Back" intends to present an overview of the possibilities and the limitations (validity and applicability) of low back biomechanical modeling in ergonomics. Generally the first step in mechanical modeling of loads on the spine is aimed at obtaining an estimate of the net moment produced by all active muscles and stretched passive tissues crossing the lumbar spine. This estimate can be obtained through standard rigid body mechanics using a 'linked-segment model'. Kinetic, and kinematic measurements are combined with individual anthropometric data to calculate the forces and moments acting on the lumbosacral junction. Since the 1980's improved motion analysis systems greatly facilitated collection of kinematic data and consequently inverse dynamic models have become commonly used in the laboratory, both still only to a limited extent in the field. An introductory paper (Jäger, et al.) presents an overview of the possibilities and limitations of inverse dynamics in ergonomic field studies. This will be followed by papers focussing on common methodological problems in field applications and solutions to these problems. In view of limitations in data collection procedures several simplifying assumptions are commonly made in ergonomic studies. Two papers (Kingma, et al.; Gagnon, et al.) illustrate the errors these assumptions may cause and present solutions to reduce these. Finally, Baten et al. present a promising new approach to estimating low back moment in field studies.

It has been argued that in order to gain more insight into injury mechanisms underlying work-related low back pain it is necessary to obtain estimates of forces acting on the spine and surrounding structures. The net moment pro-

vides a starting point for estimating these forces. Spinal forces are mainly determined by the muscle forces, which are in general much higher than the ligament forces and the gravitational force acting on the upper body and load. The estimation of muscle forces is unfortunately not straightforward. Since many muscles are spanning the lumbosacral joint an infinite number of combinations of muscle forces can produce the same net moment. Several types of models, using for instance EMG based muscle force estimates, static optimization, or neural network technology, have been developed to tackle this problem. The second session will focus on the validity of these approaches, which depend on the strategy for estimating load sharing between muscles (Perez, & Nussbaum), anatomical fidelity of the model (Marras, et al.) and assumptions regarding cocontraction (Dieën, et al.).

Biomechanical modeling can provide insight in spinal loads, which by comparison with in vitro strength data of spinal structures might even allow setting of standards with respect to load magnitude. However, this requires epidemiological verification, which may be hampered by the complexity of the biomechanical methods, precluding application in large-scale epidemiological studies, and by the nature of the suspected injury mechanisms. For example, complex or cumulative loading have been indicated by biomechanical experiments to be likely causes of injury, which can not be studied in epidemiological investigations very readily. However, recently epidemiological studies firmly based on biomechanical knowledge and expertise have been performed, which have verified the importance of task or subject characteristics which from a biomechanical perspective appear to constitute a risk. Three of the papers (Fathallah, et al.; Norman, et al.; Dolan, & Adams) will focus on this type of studies and their relationship to the underlying biomechanical experimentation and modeling. A fourth paper (Fraser and Potvin) will address the issue of unexpected loading a factor thusfar not studied extensively in epidemiology.

Finally, in the fourth session applied ergonomic studies will be presented in which biomechanical low-back modeling was used to evaluate alternative designs (Kuijer, et al.; Hoozemans, et al.), to evaluate alternative working techniques (Dieën, et al.), and to identify hazardous task elements requiring ergonomic redesign (Plamondon, et al.).